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**Toy Design for Children with Autism
Spectrum Disorder Based on Existing
Therapeutic Training Methods**

by

Ye Wang

A Thesis Submitted in Partial Fulfillment of the Requirements for the
Degree of Master of Fine Art in Industrial Design

School of Design
College of Art and Design

Rochester, NY
April 27, 2020

Rochester Institute of Technology

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Date

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Date

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Abstract

Children with Autism Spectrum Disorder (ASD) behave in different ways from other children as well as face enormous problems in their daily life. Previous research has found that physical treatment not only improves their body functions, but also benefits their mental development. Play therapy is a very effective way to help children with ASD since playing is the way children express themselves. However, after field research and benchmarking, I found that there are few toys helping them with their developmental coordination, which is necessary especially for children with ASD. In this paper, I have designed a series of devices for children with different levels of ASD to play with their different body parts to improve bimanual coordination, limb coordination and mental development. I developed and tested various colors, sizes, shapes, materials of mock-ups with children with ASD and tried to apply different kinds of feedbacks to the device. Specifically, bright colors are more attractive to children with ASD, but too bright colors should be avoided since some children with ASD have hypersensitivity with colors. Toys with a big size catch more of their attention than those with a small size despite of colors. Besides, combining materials with different softness could benefit children with ASD in therapy. Auditory elements have little attraction to children with ASD with normal sight unless it is very loud. By contrast, visual feedbacks such as light and shape change attract children with ASD more. I applied those findings to my design Bubbo-a toy designed for play therapy, which children with ASD could use to crawl on the floor or just touch and squeeze.

Keywords

Autism Spectrum Disorder, Bimanual Coordination, Toy Design, Children's Play Therapy, Physical Therapy

Dedication

First, I dedicate this thesis to Yueyue Zhang, without whom I could not finish my work smoothly and successfully. Through the whole process she gave me a lot of useful advice from her point of view and her design experience, being patient to answer my endless questions but asking for nothing.

In addition, I also want to dedicate this thesis to AccessAbility@RIT, a sponsor of my thesis. It also supported me by applying me the chance to cooperate with Rochester Hearing and Speech Center.

1 Introduction

Play is the child's language and toys are the child's words. But not all the children have the same language and the same words. Autism Spectrum Disorder is a disability caused by both genetic and environmental factors. ASD impacts the normal development of the brain in the areas of social interaction, communication skills, and cognitive function. Children with ASD have difficulties in both verbal and non-verbal communication and generally the symptoms appear before the child getting 3 years old. In the US, the diagnosed children have been climbing to an alarming one in 54 children.ⁱ At present there is no cure for ASD, but the symptoms can be greatly improved and, in some cases, completely overcome with early treatment and intervention.

Since ASD influences the brain parts that control communication, emotions and movements.ⁱⁱ Children with ASD may have problems with social interaction, cognitive function, verbal and non-verbal communication with symptoms of developmental coordination disorder. Due to these weaknesses, the symptoms of ASD often show up as having difficulty making eye contact, behaving repetitively and rigidly, being difficult to change and transit, having impaired communication skills as well as a narrow range of interests and activities.

There are various kinds of therapies for children with ASD, including Applied Behavior Analysis (ABA), Sensory Integration Therapy, Relationship Development Intervention (RDI), Floortime and so on, most of which are combined with playing more or less in practice. In other words, play therapy is the most effective way to help children with ASD. Therefore, toys with the flexibility and adaptability are needed for therapeutic playing with children with physical and cognitive challenges.

So based on the existing therapeutic treatments, how might we deliver an effective way to help physical therapists train children with ASD more efficiently, including their sensory, postural, recognitive and interacting development?

2 Review of Literature

2.1 Literature Review

Play therapies are applied to children with ASD by many experts and they believe that playing can help them improve their social and communication skills. What's more, children with ASD can also think differently, develop their language and emotional skills through playing.ⁱⁱⁱ

Due to the different development of their brain, children with ASD play differently from other children. They may focus on just parts of a toy, for instance, some may be distracted by a fastener. They don't play with pretend play toys as others do. Furthermore, children with ASD may not want to play with other children because of their social problems. However, children with ASD may use playing as their way to express themselves. In this way, people can understand them with their playing actions and build connections with them through playing.

Therefore, appropriate toys for children with ASD might be different from those for normal children. When designing for them, we must pay special attention to their characters and their needs. First of all, some of children with ASD may have extreme interest in one thing, and we need to go with it rather than against it, according to Rondalyn Varney Whitney, PhD, Occupational Therapist Registered/Licensed (OTR/L), associate professor of occupational therapy at the West Virginia University School of Medicine in Morgantown.^{iv} Second, she also opposes overstimulating children with ASD with electronic parts such as too many lights, electronic sounds and moving units, since these can damage the children and make them to be too obsessed with the toys rather than pay attention to others. What's more, thinking and designing beyond age-grade are necessary, because the intelligence of children with ASD may be different from others at the same age, some are higher and some are lower, and we cannot relate their intelligence to their age. Besides, Whitney believes that toys which could be played in variety of ways can benefit children, especially children with ASD. So, the toys should also be designed as "no-wrong-way-to-play". Last but not least, sensory inputs are desired by children with ASD, and the needs may vary among different children. For example, some may be attracted to tactile stimulation and touching, and some prefer proprioceptive stimulation such as jumping and waggling. Therefore, just-right sensory stimulation is a good feature for toys for children with ASD.

As for the color of design for children with ASD, it is an important part worth thinking about. Bright colors are more attractive to children with ASD, but we should also avoid overstimulating them with colors since some children with ASD may have hypersensitivity with colors as well.^v High-energy colors such as yellow and red are not supposed to be used in a large area of the toy because they may increase the children's pulse and tense. Pale color and natural color such as blue and green are encouraged to reduce their tension. Nevertheless, warm colors still could be used as small accessories.

2.2 Field Research

I went to conduct field research at Rochester Hearing and Speech Center to attend their class for children with ASD between ages 3 to 5 before the design process. Through the observation and interaction with the children, my findings and thoughts are as follows:

- They have a main classroom for each class, and all classes share one playroom. They use the playroom in turns. There are toys in both classroom and playroom, but the set-up in playroom are more fixed with some big-scale device, such as swing, slide and big sponge blocks. And the activities they do in classroom are more organized and in sequence.
- The center holds two or three classes at the same time. Each class consists of 3 or 4 children and 3 or 4 physical therapists.
- Physical therapists with different specialities cooperate in the same class, including speaking specialist, postural specialist, educational specialist. I categorized their work in the class as follows.

Postural training is to help the children be used to normal actions, including sitting on a stool, standing, keeping balance, lying on stomach, turning, grabbing, kicking, tapping, matching things, using both hands, activating the whole body.

Coordination training is meant to develop the children's coordination by drawing, playing with toys and so on. Physical therapists use hand-by-hand assistant training most in this part.

Psychological training helps the children to understand and remember most daily actions, such as waiting, finishing things, playing together, sharing toys, following rules. In this part physical

therapists keep talking to them about the rules or use songs to create connections with their memories.

- All of the toys are played by the children with the assist of the physical therapists.
- Feedback can encourage the children to do some actions and are important for their completing some therapies.
- Data and previous research show that children with ASD have a higher possibility to be with visual impairment at the same time.vi Children diagnosed with both diseases have more problematic behavioral traits than those only diagnosed with autism. To be specific, it is harder for them to recognize distance and they are very sensitive to sounds. What's more, they cannot identify colors unless it is very close to their eyes, and they recognize shapes only by touching. Therefore physical therapists usually need some special training aids when playing with these children, such as to encourage them to move their body with a tinkle of bells, or to put toys with very bright colors near to their eyes.

2.3 Benchmarking

A lot of toys for children with ASD on the market have a tactile sensory feature. In comparison, toys for their proprioceptive and coordination treatment seem few.

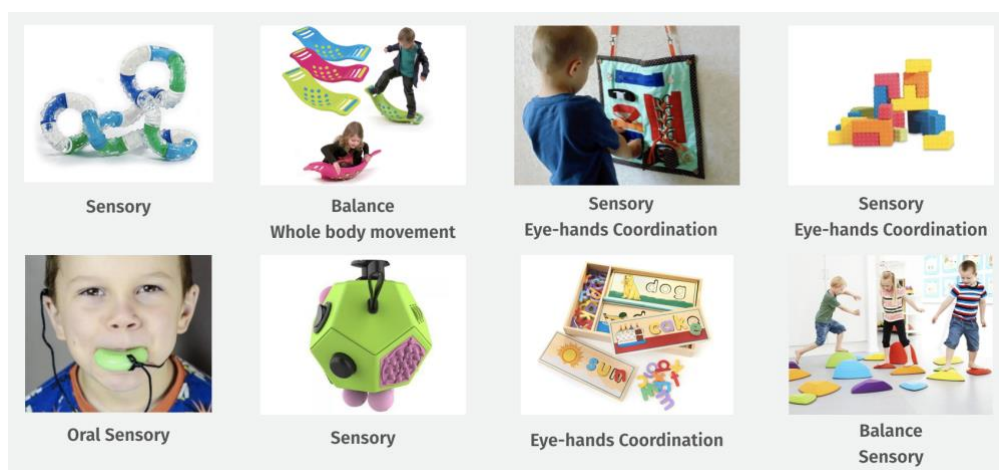


Figure 1: Toys for Children with ASD on the Market

Also, during my observation at Rochester Hearing and Speech Center, I found that most toys they are using are either made by therapists themselves, or are general toys which are not designed for children with ASD.

Although most toys for children with ASD have the features to fit their needs, the toys are for children to play by themselves, which is very hard for physical therapists to play together with children, or play with children at the same time as taking care of them. For example, the boy in the first figure is very irritable and cannot stand by himself, so the physical therapist needs to control him at the same time and set up the blocks, which is a very difficult process.

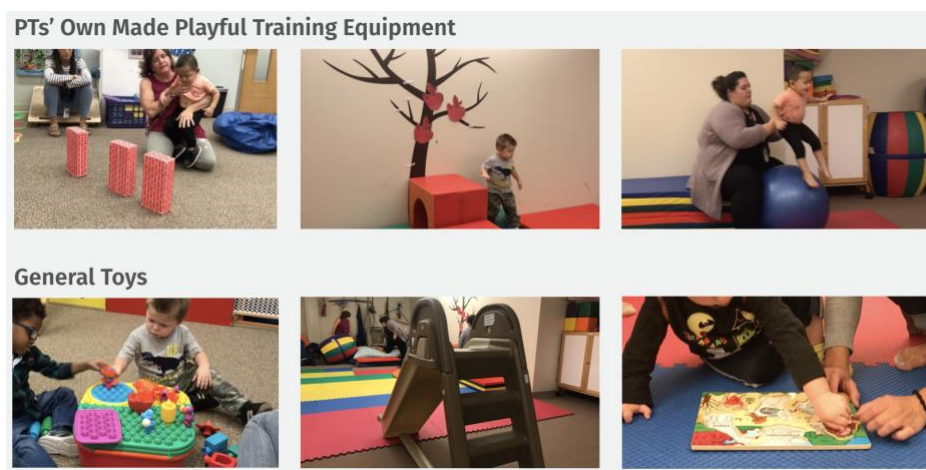


Figure 2: Toys in Rochester Hearing and Speech Center Made by Physical Therapists (Photo by the Author)

Therefore, the gap needs to be filled with more options for toys that the children and the physical therapist can use together. Further, the toys need to be easily used as well as benefit children with ASD. To meet this need, a good understanding of the characteristics of children with ASD and their class is required for the designer.

2.4 Interview

In an interview with Lucy Liu, a mother of an 18-year-old boy, who was diagnosed as ASD at 2 to 3 years old, I got the chance to know how much difficulty it is to overcome this problem. When asked why not bring her son Nick to a therapeutic center, Lucy says “We had to educate Nick at home since there are too many children waiting for a position.” Because the number of children with needs are too large and the classes are just a few, she and her husband dropped him to a school with daily childcare when

he was young, and educated him at night. “He will keep a habit only if we have kept telling him for years,” says Lucy, “we love him but we know we must train him very strictly, or we will destroy him.” When training him, Lucy and her husband keep their attitude with both love and strictness, not to spoil him because they know that’s not good for him. Now Nick can accomplish many basic daily habits and almost live daily life by himself, including eating, brushing teeth, using the bathroom and so on. Lucy also mentioned another boy they know who also has ASD. His family spoiled him rather than trained him, therefore he still has low function. For his toys, Nick didn’t show much interest in them at home, but he was attracted by toys with sounds.

2.5 Persona

Mary - Experienced Physical Therapist, 45

Mary’s job is to educate and teach kids every day. She repeats and correct kids on the same things a lot of time. She works 6-9 hours per day. After work she is tired both physically and mentally. Besides classes, she also has conferences with other physical therapists.

Peter - Child with Autism, 3 year 5 month

Peter is a little boy with a quiet and peaceful personality. He doesn’t have a good understanding of the verbal world so he doesn’t usually express himself. Sometimes he just stares blankly. He barely obeys rules when playing and forgets things a lot, but he is very creative in his own way.

George & Christine - Parents, 27

George and Christine are new parents with busy work. When they realized Peter had ASD they were very nervous. They had no experience dealing with it and this adds more pressure to their life. Although they are exhausted after work, they spend most of their spare time playing with Peter.

2.6 Design Opportunities

The following are opportunities for interacting with children with ASD and feasibility analysis of each direction:

- a) Postural Training

- Sitting on stool, standing, keeping balance
- Lying on stomach
- Turning, grabbing, kicking, tapping
- Matching things
- Active the whole body

b) Sensory Training

- Texture
- Sticky, cold, hot, gooey (touch/skin feeling)
- Oral sensory

c) Coordination Training

- Bimanual coordination
- Eye-hand coordination
- Whole-body coordination
- Finger/hand muscles

d) Psychological Training

- Waiting
- Finishing things
- Playing together and sharing
- Following rules

From previous research, it's hard to achieve the function of postural training and psychological training only with a toy. These habits rely more on intervention by physical therapists. And there are many toys that focus on sensory stimulation existing on the market. Therefore, designing with coordination training for children with ASD can help them to the maximum extent.

3 Design Process

3.1 Ideation – Mind map of problem

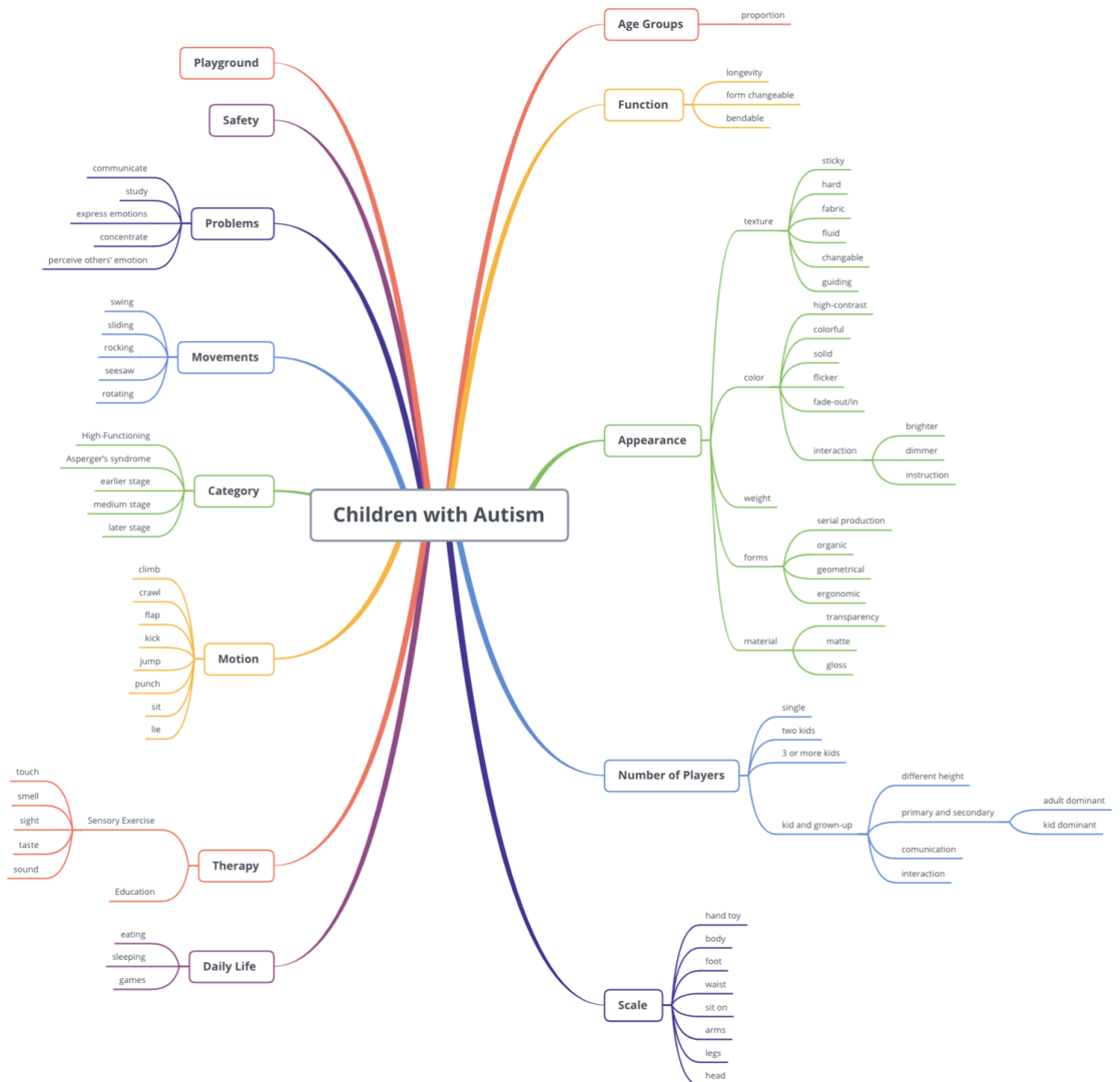
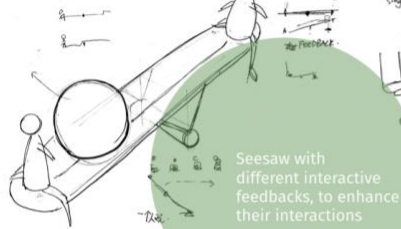


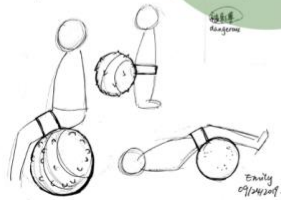
Figure 3: Mind Mapping Related to Children with ASD

Ideation

SEESAW & BALL



SENSORY BALL



INTERACTING SHEET

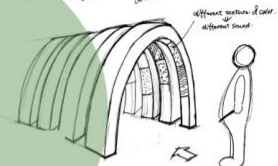


MY FANTASTIC SPACE



A private sensory space to make them feel more relaxed

INTERACTING ARC

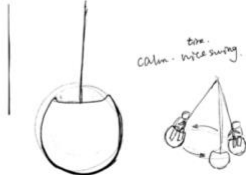


VOCAL CLAY



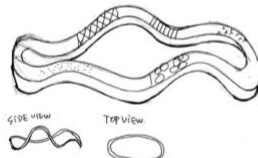
Motions to release their tension

ROTATING SWING

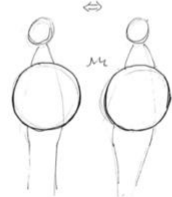


Ideation

PLAY RING/RIBBON



WALKING BALLOON



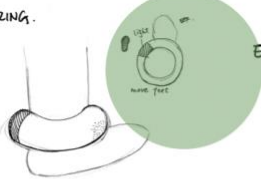
SEESAW



TEXTURED LAD



ANKLE RING



ELECTRIC DRAGONFLY



CHEWING

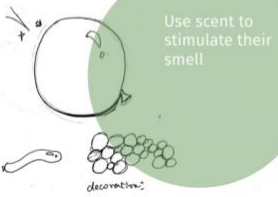


TANGLE TOY



Ideation

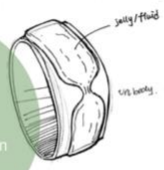
POKE SACHET



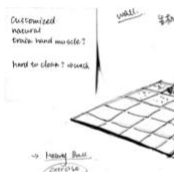
Use scent to stimulate their smell



SQUEEZE JELLY

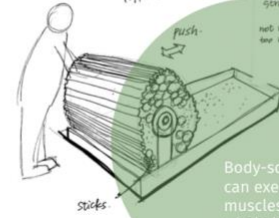


SENSORY FLOOR



DIY sensory board, also can exercise their whole body

MUSIC BOX



Body-scale equipment can exercise their muscles from the whole body

BUBBLE POOL



FOR PT: HOW TO SELECT



Figure 4: Ideation Process

3.2 Early Concept

3.2.1 Early Concept Description

From the research and ideation process, I decided to develop a small device to help improve bimanual motor coordination of children with ASD. The mechanism of the whole device is like a small seesaw, so the children could play with their both hands. When playing, the children need to open and close their hands alternately, which could benefit their motor coordination development as well as muscular strength on the hand.



Figure 5: Ideation Process
(Photo by the Author)

Then several versions of mock-ups are developed with various scale, shape, and elements as shown in Figure6.

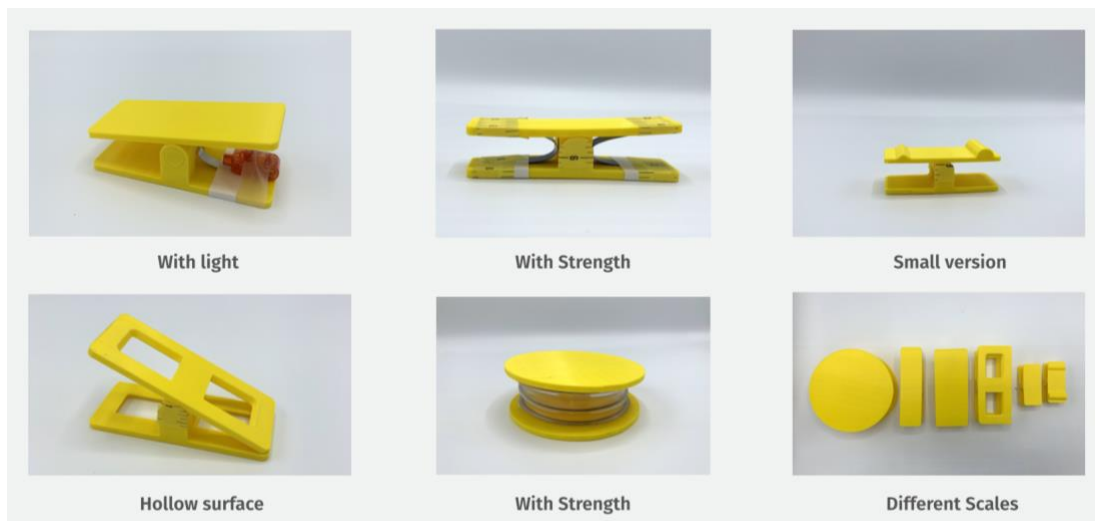


Figure 6: Early Mock-ups with Different Design Elements (Photo by the Author)

3.2.2 Early Concept Testing

Time: 11/06/2019 1:00pm-2:00pm

Location: Rochester Hearing and Speech Center

Conclusions:

- The children interact differently with the toys with various shapes and sizes:

Big round – rotate.

Big board – push on the top.

both hands move together.

both hands coordination in another direction.

Small board – fits their hands better.

- In this situation, the children's behaviors are rules to guide the design. So choosing several of the above-mentioned motions and combining them into a "no-wrong-way-to-play" toy may be a good solution.
- Since the children's interaction varies due to different shapes, appropriate shape should be used to lead children to expected motions.
- Compared with a flat board, the hollow ones may make more sense for them to squeeze.
- Among all the mock-ups, children are most interested in the light as feedback. The click sound of boards has less attraction, which may be because the sound is too quiet.
- Most children with ASD would like to imitate what physical therapists did when they played the mock-ups the first time.
- The interaction between two toys could be effective to encourage interaction among the children or between the children and the physical therapists.
- Another thought about the way to create connection between several pieces of toys is that each piece can be made as a module and the child can stack them to create new things.

3.3 Refined Concept

3.3.1 Refined Concept Description

From the first testing, the small size fits the hands of the children better, so more development and ideation are created with this scale.

In order to keep children doing the motion, toys need to attract their attention. Hence, the way feedback happens is very important. The round mock-ups give more opportunities for feedback, including visual, vocal as well as tactile feedback, and working mock-ups are made for testing. Typical ones will be explained as follows:

a) Balloon - visual feedback and tactile feedback

This is an idea developed from the original small board. A colorful balloon is added between the two boards in order to give the children an obvious visual

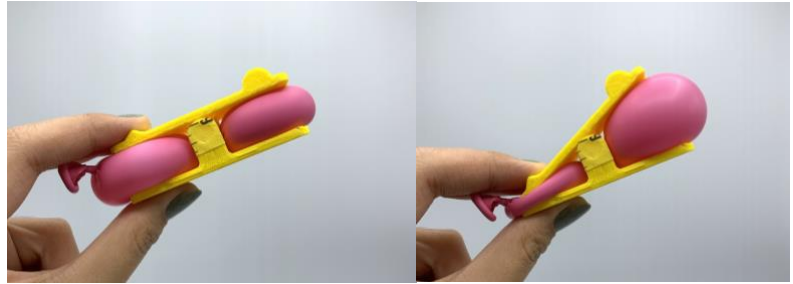


Figure 7: Mock-up with a Balloon (Photo by the Author)

transformation during the interaction. Besides, different materials could give various sensory stimulation to the children and benefit their therapy.

b) Balloon with beads inside – visual and vocal feedback

Another type of mock-up combines both visual and vocal formats of feedback. It looks the same as the one in Figure 7 from the appearance, but there are materials inside the balloon. Different types of beads are put into different mock-ups, including metal beads and plastic beads. So when the children shake the mock-up, different sounds could be made.

c) Pinch 360 degrees - match the edges

Figure 8 is a mock-up that made based on the idea to train children's fine motor skill by matching the "teeth" on the edge. This mock-up is developed from the "seesaw" mechanism. The spindle in the middle is moderately tight so the children's hand muscle can also be improved during the



Figure 8: Mock-up with Matchable Edges (Photo by the Author)

process.



Figure 9: Mock-up with Balloon and Slime (Photo by the Author)

d) Balloon with slime inside – visual and tactile feedback

This mock-up uses slime inside the balloon instead of beads. Though it won't make obvious sound when being interacted, it does have an ambiguous feeling when being touched. This feeling may comfort some children with ASD.

e) Balloon with Light - visual and tactile feedback

As showed in Figure10, Light element is added in this idea. So are the balloon and the texture. The difference between this mock-up and the previous ones is that the turning mechanism is removed in this one. And it takes advantage of the elasticity of the balloon.

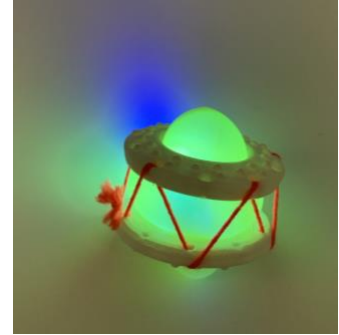


Figure 10: Mock-up with Balloon and Light (Photo by the Author)



Figure 11: Some Refined Mock-ups (Photo by the Author)

3.3.2 Refined Concept Testing

a) Statement

In order to help the children develop their finger motions and bimanual cooperation better, there are some refined pieces. These ones are more playful than the old ones with a feedback given to them while playing, hopefully also can attract their attention longer.

b) Questions for physical therapists

1. Which one in these pieces you find **most interesting**?
2. Why do you think this one is most interesting?
3. Which one in these pieces you find can be **most helpful** for their treatment?
4. Why do you think this one is the most helpful?
5. Do you think the jagged edge will **distract their attention** from the whole piece?
6. Is there any **potential issue** with the pieces that may concern you?
7. What else do you want to share, but I didn't ask you about?

c) Observation

- Children's most interested one (may be different from PT's)
- How do they interact with the toys
- Children's strength and appropriate intensity
- Appropriate size

Time: 02/27/2020 1:30pm-2:30pm

Location: Rochester Hearing and Speech Center

Conclusions:

- The mock-ups can be evaluated from two angles - keeping the children busy and helping with their therapies. The current mock-ups have good qualities and the children are interested in them. So it achieves the goal to keep the children busy. But there are still some opportunities to combine the toys with some activities that the physical therapists are using in the children's intervention. For example, a band can be added to tie the piece on their hands, so that the children can feel the elastic sensation while crawling on the floor.
- Children with normal vision are attracted by loud sounds, such as hitting a bell or playing a song. But children with visual impairment can notice very trivial sounds and are fond of making sounds by themselves, even clapping two pieces of the toy together to hear the sound. So the sound made by shaking is too quiet for children with ASD but without visual impairment, because the beads are a soft material, and they are more attracted by visual elements. Besides, the children barely

shake the mock-ups, which shows that the shape of the mock-ups does not make sense to the children to do the shaking motion.

- The touching feeling of the elastic ball filled with slime is more attractive than the seesaw mechanism.
- When the children interacting with the mock-ups, though small ones can fit their hand size better, big ones do attract more of their attention at the beginning.
- The children like to throw things. The soft ball with hard accessories may upspring towards an unexpected angle. The design needs to keep the children safe.
- The tails of the balloons on the mock-ups can distract the children with ASD.
- The moderate holes - the same size as the children's fingers - on the mock-ups attract the children to put fingers on it.

3.4 Final Concept

A series of toys named Bubbo with several games that could improve development of children with ASD in several different levels. Each toy of the series has common elements – elastic balls of soft material combined with hard parts, as well as common design language – soft and friendly shape. Here listed three of them and its possible games to play with children with ASD and physical therapists.



Figure 12: Sketches of Final Concept

The first is showed in Figure12(a), which could be strapped to the children's hands and give them sensory feedback when they crawl on the floor. This game could help with whole-body intervention and muscular exercise of the children with ASD.

The second one is a soft ball with three rigid plates with textures and dimension as showed in Figure12(b). Children with ASD can match the shapes of the plates with the corresponding depressions on the board. This game can help develop the children's shape recognition, hand-eye coordination and sensory stimulation.

Figure12(c) shows the concept of the last one. The children with ASD can use the different shapes as different animals and tell stories about them. They can also color the white faces with markers repeatedly using their imagination. This game can mostly develop their intelligence, visual imagination as well as speaking ability.

Therefore, these three toys could develop children's ability in three deferent levels. What's more, all the three toys can also be played by themselves, so they are "no-wrong-way-to-play".

3.5 Final Model

There is one toy in Bubbo series with refined shape and model shown in Figure13. This is a developed model with the idea explained in Figure12(a).

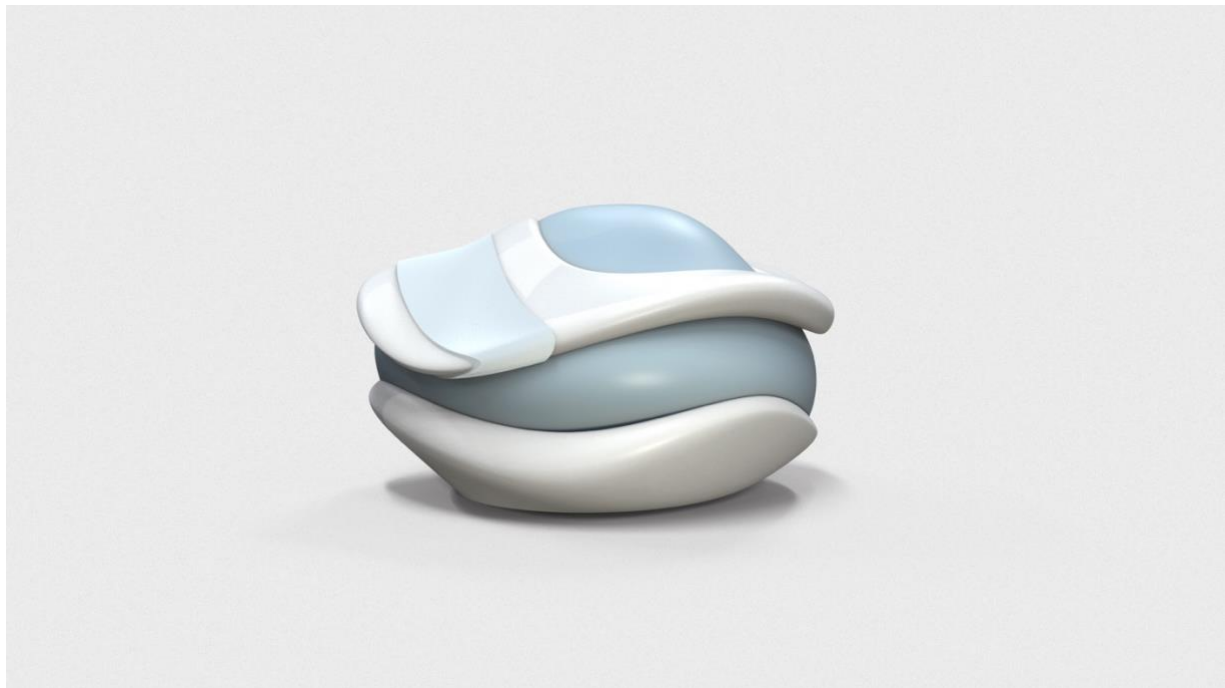


Figure 13: 3D Model of Pebble

The name of this toy is Pebble. Two covering parts (white parts) are made out of TPU. Its curve and size provide children with ASD a good and comfortable hand feeling. The fabric band on the plastic is stable and elastic, so it can fix children's hand with different sizes but won't hurt them through their naughty playing process. The middle part is an elastic ball. It feels very soft and comfortable when touched. It is pressed by the two covering parts and applies the toy with more fun. The shape of the whole toy looks very soft, friendly and inviting. Children with ASD can be calmed down with the color of pale blue. The color can also represent nature, quiet and calmness. Children with ASD can use Pebble to crawl on the floor, feeling the different sense from several materials, or play it as a piece of playful toy.

4 Summary

This project was greatly helped by observing the children and interviewing the physical therapists. By attending the classes of children with ASD by myself, I have the chance to notice more details that I could never get in a literature review, such as the hand-by-hand training method and the different ways they express themselves. Observing and playing with children with ASD also let me get the testing data more directly. Those are all very precious in design, especially in the process of understanding what the user really needs. Besides, in this environment I can feel how hard physical therapists work even only with one child, leading me to consider more from the point of view of physical therapists.

To design for children with ASD to aid play therapy, the understanding of autism and play therapy is necessary. In the research, the opportunity to design a toy to develop the children's coordination is found, so is the need of a user-friendly toy for physical therapists training children with ASD. With the findings from the observation, a plenty variety of mock-ups are built. Then after testing and evaluating from physical therapists, the one combined both soft and hard materials is considered most valuable. More testing needs to be done to find the shape that is comfortable for the children's hands to press on as well as the way that is easy to put the toy on the children. Therefore, the final result is user-friendly either for children with ASD or for physical therapists. The concept of Bubbo and further developed model of Pebble reach the goal to assist physical therapists with play therapy with their function and friendly shape.

5 Conclusions

This research points out many possible design directions for children with ASD and details in their life from an observer that participated in the children's class and therapy. Therefore, this paper has much reference value to those trying to get a better understanding of children with ASD. The paper not only analyzed the traits of children with ASD, but also considered the problems that physical therapists face in the play therapy process, which is very few in previous research. The design result fills the gap of the marketplace and shows a great usability to both children with ASD as well as physical therapists when put into practice. It applies a game that can develop the whole-body coordination of children with ASD and benefits physical therapists with a concise using process.

Based on the research and design in this paper, further development would be to refine and test the shapes of other toys in the series Bubbo. Pebble in this series is a successful and well-developed product. Therefore, the rest ones could use the same design language of organic shape and using of textures. But the specific forms and appearances still need to be tested and discussed.

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